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THE MISSISSIPPI RIVER FLOOD OF 1912

BY

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Floods in rivers are annual occurrences. They are the result to a large degree of the changing seasons following the annual migration of the planetary wind belts. Floods in any one stream, however, vary in many ways, notably in height, in duration and in the time of the high stage season, during which they are dominant. It is necessary to realize in the first place, in discussing the great flood of 1912 in the Mississippi River, that a flood is a normal event in the river, and then to search for the variable features which have made a normal flood excessive.

As the Mississippi River drains a vast area and the headwaters of its tributary streams are in widely separated portions of the country, no one single flood, as a rule, passes down the trunk stream, but a series of flood waves which correspond to the spring rises in the different large tributaries. In consequence, the high stage of the river usually extends over a period of six months, from January to June inclusive. The Ohio, Missouri and the Upper Mississippi tributaries yield 63 per cent. of the total discharge of the river and are the prime factors to be considered. The Ohio district has its heaviest rainfall usually during January, February and March. Its large tributaries, the Cumberland and the Tennessee, rise in the southern Appalachians in a region of copious rainfall and add an enormous volume of water to the Ohio. The Ohio streams are in the track of the storms which come from the Gulf and although the entire basin of the Ohio River is less than one-half that of the Missouri, it furnishes over twice as much water to the Mississippi (of the 63 per cent., the Missouri contributes 14, the Ohio 31, and the Upper Mississippi 18).

The Missouri River basin has its rainfall in May and June and is the source of the late floods of the Mississippi. Although the Missouri has the largest drainage area of any of the tributaries, yet, because of the scant rainfall over the district and the small percentage of run-off due to an absorptive soil, it is hydrologically the least important. The upper Mississippi River has its heaviest rain-

fall in May and June also and its rise unites usually with that of the Missouri. The ordinary sequence of floods is first the Ohio, then the Upper Mississippi, followed by the Missouri with the western streams. It is a common statement but well worth repeating that these streams have never been known to be in excessive flood at the same time. Such a coincidence would produce a discharge of more than 3,000,000 cubic feet per second, twice as large as has ever been observed.

The variable features in the Mississippi River floods are:

1. The amount of rainfall. Excessive rains are the prominent cause of all great floods. The 1907 flood was due to heavy rains in the Cumberland-Tennessee districts during January. The 1903 flood was caused by excessive rains during early March and the 1912 flood was the result of a succession of heavy storms during the last of March and early April.

2. The condition of the ground as to moisture. The most obvious example of this would be a rainfall of two inches extending over three days, which may produce only a very slight rise in a river, while the same amount in two hours may produce a very great one. A number of storms in rather rapid succession would have the same effect in increasing the percentage of run-off and this circumstance was the experience last spring.

3. Condition of the ground, whether frozen or vegetation covered. The run-off of the 1907 flood was high because the rain came during January when the ground was frozen. In general the Ohio floods come before the frost is out of the ground, so that a heavy rainfall is almost surely followed by a full stream. The question of the effect of the vegetation cover is a mooted one. M. I. Leighton believes that an increase in flood tendency has been caused to a great degree by the denudation of forest areas. On the other hand, Smith says* with considerable confidence that the question of increasing flood conditions and increasing low-water periods is fairly settled in the negative, so far as the available stream flow data can settle it.

4. The height at which the flood finds the lower trunk. The 1903 flood was emptied into the lower Mississippi at a time when the lower tributaries, such as the St. Francis, White, Arkansas, Yazoo and the Red Rivers, were at an extensively high state. A similar condition existed during the 1897 flood, which made the gage readings of the lower Mississippi stations for these two floods higher

* J. Warren Smith. "The Relation between the Precipitation over the Watershed of the Ohio River above and the Stream-flow at Cincinnati." *Bull. 40, Weather Bureau, U. S. Dept. of Agric.*

than during any flood of the period 1882-1911. During the 1912 flood the lower river was at a high stage when the Ohio flood reached it and the gages of this flood were in excess of any which had been recorded.

5. The duration of the rise. The length of time which a flood is at or above the danger line determines in a measure the amount of territory that is threatened. A sudden rise up river flattens out as it proceeds down stream and thus a high stage of slight duration at Cairo may be insignificant when New Orleans is reached, while a series of rises up river tends to promote dangerous conditions in the lower river in counteracting the flattening tendency by additional volumes of water.

6. Local rainfall in the lower valley. Not only were the lower reaches of the Mississippi River in flood from the Missouri when the Ohio flood waters reached it, but the condition was aggravated this year by excessive rainfall, which in itself caused the towns of the lower valley to suffer because of the impossibility of draining off the surplus. New Orleans could not, for instance, take care of the rainfall when the high stages of the river were threatening the city with further disaster.

CONDITIONS CAUSING THE FLOOD OF 1912.

The precipitation during January and February over the greater part of the basin of the Mississippi was much below the normal. At Topeka, for instance, the January normal is .93 inch., the departure last January was — .79 inch, making an actual total rainfall for the month of but .14 inch; at Bismarck, the figures read, normal .54 inch, departure this year from normal, — .34 inch, actual precipitation .20 inch; at St. Paul, normal .90 inch, departure last January, — .38 inch, precipitation .52 inch; at Pittsburg, January normal, 2.87 inches, departure this year, — .97, actual precipitation 1.90 inches; at Nashville, January normal is 4.85 inches, departure this year — 1.93 inches, actual precipitation 2.92 inches. The only area not reporting a deficiency for January was a belt extending from Memphis to Indianapolis (Fig. 1). The snowfall in southern Illinois was heavy and Cairo's departure from the normal for the month was + .31 inch (in snow), making a total precipitation for Cairo for the month of 4.13 inches. During February a slight increase over the normal fell at Topeka (normal for February 1.44 inches, departure this year + .14 inch, actual precipitation for the month 1.58 inches). Practically no rainfall was reported for Bismarck (normal for Feb-

ruary .52 inch, departure this year, — .42 inch, actual precipitation .10 inch), or for St. Paul (normal for February .87 inch, departure this year, — .80 inch, actual precipitation .07 inch); while Pittsburg (normal for February 2.75, departure this year, — .95, actual precipitation 1.80 inch) and Nashville (normal for February 4.46, departure this year, — .25, actual precipitation 4.21 inches) fell below the normal precipitation. The exception in the case of Topeka was caused by snowfall over Kansas and Nebraska. The snowfall on February 25th in Kansas was the heaviest since 1900, and the total monthly snowfall ranged from six to twenty-four inches. At the end of the month a considerable body of snow covered the ground

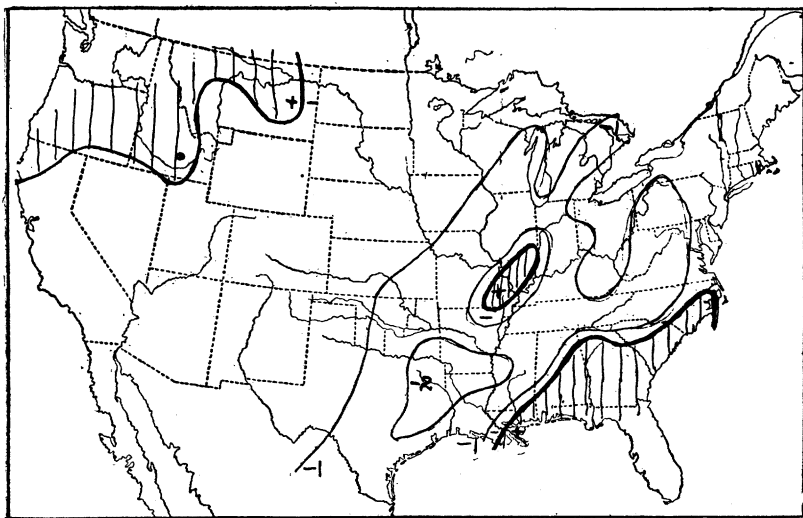


FIG. 1—Departures from Normal Precipitation for January. From No. 1—*National Weekly Weather Bulletin for 1912*. Heavy line mark the places of normal rainfall; shaded portions show excess (+); unshaded portions deficiency (-); light lines show amount of excess or deficiency, in inches.

from western Kansas to eastern Colorado, extending northeast to the Lake region (Fig. 2).

During March and April, except in the north, where the deficiency of precipitation continued, an abundant rainfall was reported. The flood conditions were inaugurated in the Missouri basin, with Missouri, Iowa, Kansas and Nebraska under the cover of excessive snow. Early March added to the amount of snow on the ground and in Nebraska the monthly snowfall (March) was the greatest for at least thirty years. With so deep a snow cover at the end of the season, it is natural to expect high stages in the rivers because of the

possibility of a rapid removal. Heavy rains and high temperatures during the middle of March melted the snow and caused unusually high stages on the lower Missouri, and this water caused a flood of moderate dimensions in the Mississippi. Following directly upon this, the excessive flood from the Ohio River came into the lower Mississippi.

In general, the rise of water from the Ohio begins early in January. In the 1907 flood the rise began as early as November 16, 1906. During 1912 the general deficiency of rain over most of the basin during January and February delayed the beginning of the Ohio flood. This flood is inaugurated by a southwest storm bringing

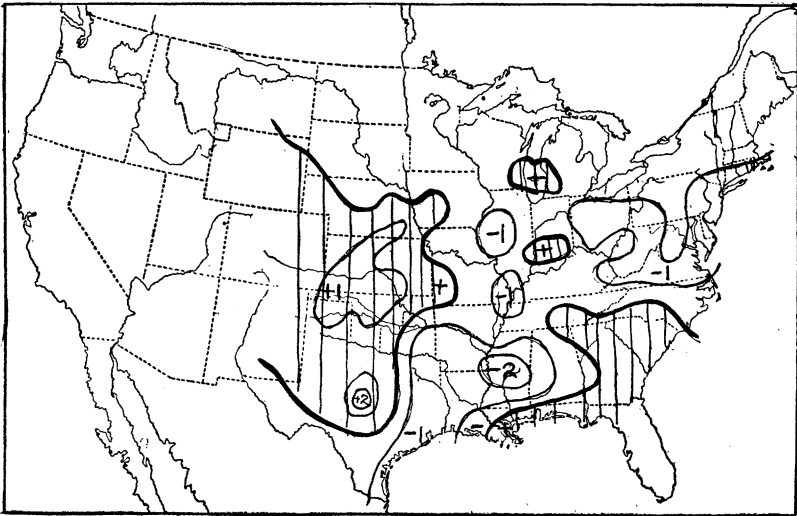


FIG. 2—Departures from Normal Precipitation for February. From *National Weekly Weather Bureau, No. 2, 1912*. Heavy line mark the places of normal rainfall; shaded portions show excess (+); unshaded portions deficiency (-); light lines show amount of excess or deficiency, in inches.

heavy rains and high temperatures. Because of heavy snow in the Missouri basin and slight precipitation in the Ohio, the ordinary sequence of floods was changed, and instead of Ohio, Missouri and Upper Mississippi, the order this year was, Missouri, Ohio and Upper Mississippi. It is worth while to note in passing that the same conditions which caused the Missouri flood did not exist over the Upper Mississippi area, but in figuring flood possibilities it behooves us to realize that they could have existed without any record breaking precipitation in the north. The unusually dry winter over all the northern part of the country was providential from the point of view of the flood stages in the lower river.

The Ohio River began to rise after March 11, following the first of a series of southwest storms. This storm occurred on March 11-12 and it brought heavy precipitation throughout nearly the entire central and southern portions of the country. A second storm, March 14-15, moved over nearly the same course as the storm of March 11-12 and it was accompanied by heavy precipitation over most of the area. Following this storm the first warning was sent out on March 16, by the Weather Bureau. A third storm, March 20-21, was accompanied by moderate rains. At this time the Ohio River at Cairo had passed the 45-foot level. The entire Ohio was in flood, at Pittsburg the river was 6.1 feet above the flood stage. A

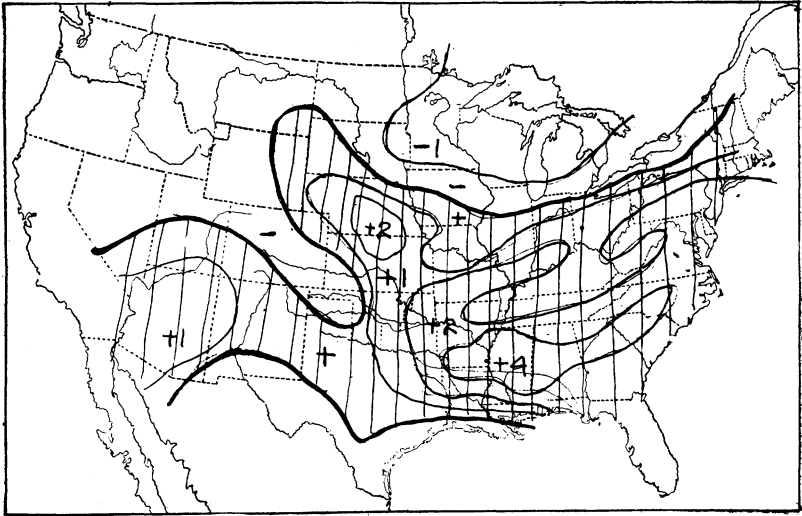


FIG. 3.—Departures from Normal Precipitation for March. From No. 3—*National Weekly Weather Bulletin for 1912*. Heavy line mark the places of normal rainfall; shaded portions show excess (+); unshaded portions deficiency (-); light lines show amount of excess or deficiency, in inches.

fourth southwest storm set in on March 23-4 with unusually heavy precipitation and high temperatures, and a fifth on March 28-9 passed over the same area, again with heavy precipitation. At the end of the month, the highest stages of the river ever recorded were predicted between Cairo and Memphis; the water at Cairo was then at 51 feet, higher than during the 1903 and 1907 floods, and at Memphis, 38.1 or 3.1 feet above flood stage.

Altogether the precipitation for March was far above the normal. At Memphis with a normal for March of 5.77 inches, the departure for the month was + 3.76 inches, making a total monthly rainfall of 9.53 inches, and at Pittsburg the excess was 1.82 inch. The ex-

cesses for the month over the area drained by the river were from two to five inches. (Fig. 3.) The rainy condition continued into April. On April 1-2 another southwest storm brought heavy rains. This was, however, the last of the series of storms which brought unusual rains and which easily account for the stages of the Ohio. The rapid succession of the storms made the extreme stages continue longer than usual by supplying a fresh burden of water and made the flood condition in the lower reaches of the river hazardous. It was not until May that New Orleans began to suffer, and on May 9, Governor Saunders of Louisiana sent out his appeal to the Nation to protect his State from flood. After the middle of April, rains began to be excessive again and now the lower river received the brunt of the storms. For the week ending April 22, 1912, the precipitation ranged from four to eight inches above the normal over the lower parts of the Mississippi Valley. Mobile for the week reported a departure of + 10.53 inches with a normal of 1.07 inch. The rains continued into May, and at New Orleans the rainfall on April 30 was 1.2 inch, on May 6, 2.44 inches, May 7, 1.06 inch, May 10, .76 inch, and May 11, 6.94 inches.

In summing up the reasons for the excessive flood, it is evident that very heavy precipitation over the Lower Mississippi and the Ohio valleys was the prime reason. The lateness of the Ohio rise, however, allowed the Missouri flood which came from the melting of a heavy snow cover to reach the lower Mississippi almost simultaneously with the crest of the Ohio flood.

SOME CONDITIONS DURING THE FLOOD OF 1912.

The complete data of the 1912 flood have not been issued at the time of this writing, but enough has been published to give a good basis for comparison with the floods of other years. The 1912 flood at nearly every station on the Mississippi exceeded the highest gage reading since 1871, when river gages were first established along the river. Thus at Cairo, the record was 54.00 feet, the highest previous being 52.2 in 1883; at Memphis, 44.9, the highest previous being 40.3 in 1907; and at Helena, 54.2 as against 51.8, the highest previous in 1897. Frankenfield* is authority for the statement that the volume of water of the 1912 flood was greater than that of the 1907 or the 1903 floods but less than that of the 1897 flood, and he has arranged the floods in order of volume of water, beginning with the greatest, thus; 1897, 1912, 1903, 1907. At Cairo, the 1897

*H. C. Frankenfield. "The 1912 Floods in the Ohio and Mississippi Rivers." *Engineering News*. Vol. 67, p. 747. Apr. 18, 1912.

flood was above the flood stage (45 feet) 48 days, the 1912, between 40 and 45 days, the 1903, 25 days, and the 1907, 16 days.

The Mississippi River Commission has for a number of years adopted the policy of placing the grade of the levees at two feet above the estimated gage measurements of the highest flood. Thus for a while the provisional grade was two feet above the 1897 flood. Later the 1903 flood set a new mark and a grade two feet above the 1903 high water was made the limiting height of the levees. At Lake Providence, the 1903 water mark was two feet above the 1897; at Greenville, it was 2.4 feet above. Accordingly, the high water of 1903 reached to the top of the levees suggested after the 1897 flood and a new height two feet above the former estimated height was demanded. This latter height is about five feet above the provisional grade just before the 1903 flood. At Lake Providence and at Greenville these provisional grades have continued. The ultimate high water estimated by the Mississippi River Commission, based on the 1903 flood, was for Lake Providence 48 feet, and for Greenville 50.50 feet, which would place the levees at 50 and 52.50 feet respectively but in 1898 these were raised to 51 feet and 54.8 feet. The 1912 flood reached 48.25 at Lake Providence and 50.50 at Greenville, at almost the estimated figures. The loss of flood height due to the breaking of the levees and the release of water from within the levees is not considered. The estimated height will in all probability exceed the levee heights at these stations. At Cairo the highest previous record was in 1883 at 52.20, and the high water estimate was placed by the Commission at 54.17, which made the provisional grade 56.17 feet. The high water of 1912 reached to 54 feet at this station, and both Dabney and Frankenfield have estimated that the water would have reached the top of the provisional grade had not the levees in the locality given away and drained off a large volume of water. At Memphis, the water actually rose 3.3 feet above the Mississippi River Commission's estimate and overtopped the levees. The 1912 flood will cause the provisional grades for practically the whole reach of the river south of Cairo to be changed.

The efficiency of the levee system is the test of all the labor and the justification of the large expenditure. Efficiency may be measured in many ways. A comparison of the number of crevasses and the total number of miles of destroyed levees with the record of previous floods is the one in general use. During 1882, 284 crevasses were recorded and 59 miles of levee were destroyed. This record has been gradually improved. During 1890 only 23 crevasses were reported and 4.25 miles of levee were destroyed; during 1897, the

number of crevasses increased to 49, with a loss of 8.3 miles of levee; during the 1903 flood, 9 crevasses of importance were recorded and 5 of these caused a loss of 2.1 miles of levee; and during the 1907 flood, the breaks were practically negligible. The 1912 flood found a passage through 22 crevasses, which aggregated not far from 22 miles in length.

From the analysis of the overflow made out by Dabney,* the conditions of some of the larger crevasses were as follows:

1. Upper St. Francis Basin, State of Missouri. Two breaks aggregating 22,000 feet occurred in levees that had been built by the county districts. The districts were protected by sack topping on the levees which were 4.5 feet below the standard grade, and the water stood 1.5 feet above the top of the levees when the break occurred. Practically all of the district of 700 square miles was flooded.

2. The Hickman break in Kentucky. The levee was three feet below the standard grade and the height had been increased by sack topping. The water was one foot above the levee when the break occurred. The break was precipitated by a wind storm which caused a wash and the sack topping was undermined. All of the 310 square miles protected by this levee was inundated.

3. The Lower St. Francis, State of Arkansas. Three breaks which flooded 2,500 square miles of territory is the record here. At all of these stations the levee was from one to three feet below the standard grade and at two the water was above the levee at the time of the break.

4. Ten breaks in the Louisiana districts flooded about 2,800 square miles of territory. In practically all of these cases the water stood below the top of the levee at the time of the break. The reasons for the breaks are given as sandboils in two cases, cuts in two cases and one case each of sloughing on landside, enlargement, unstable substrata, crawfish holes, cut for roadway improperly filled and overtopping. There is no doubt that the breaks in the levees and the consequent discharge of the water from the high water channel made a lower stage for this flood at all places in the river from Cairo south.

EFFECTS OF THE FLOOD.

The final estimate of the damage done by the 1912 flood cannot now be given, but certain approximations may be stated. Early in April, the Government estimated that the flood had already rendered

* A. L. Dabney. "The 1912 Flood on the Lower Mississippi." *Engineering News*. Vol. 67, p. 1121. June 13, 1912.

30,000 people homeless and caused a financial loss of \$10,000,000, but this was before Louisiana had suffered the flood ravages. Early in May, the Governor of Louisiana sent out his appeal to the nation and in it he stated that in his territory 350,000 people had been affected by the flood. In the northern parishes out of 125,000 affected, the government was caring for 30,000 and in the southern parishes approximately a quarter of a million people were in some way affected, of whom at least 100,000 people would suffer loss and probably 40,000 people would eventually have to be cared for by the Government before they were able to get back to work again on their lands. The estimated damage by inundation is given at \$6,000,000 and this will be increased considerably if the water does not drain from the cultivable areas in time for the planting. The same source announced that the total loss of life in Louisiana had not exceeded 20 and in all cases the cause was accidental, only indirectly due to the flood conditions. In general the efficiency of the Weather Bureau in issuing flood warnings is so high and the value of these warnings has been so ably demonstrated in other years, that the loss of life is now practically reduced to zero, although, as is to be expected, the stress due to unusual and especially portentous conditions increases the liability of accidents.

The territory inundated according to Dabney's analysis was practically all of the Upper St. Francis district on the west bank of the river in Missouri, about 700 square miles; 11 square miles of the Cairo drainage district in Illinois; all of the Reelfoot district, 310 square miles, on the east side of the river in Kentucky and Tennessee; 80 per cent., or about 2,500 square miles, of the Lower St. Francis district on the west side in Missouri and Arkansas; 80 per cent., or about 730 square miles, of the White river district on the west side in Arkansas; 50 per cent., or about 1,300 square miles, of the Lower Yazoo district on the east side in Mississippi, and some 3,000 square miles of the Louisiana districts on both sides of the river. Many towns suffered in one way or another and among the settlements wholly or partially inundated was Columbus, Mo., Hickman, Ky., and Memphis, Tenn.

Whenever a great flood passes down the Mississippi River, the possibility of a greater is at once apparent. And as the settlements on the flood plain are tending to increase, partly because of the protection during periods of minor floods given by the levees and partly because of the confidence invited by the Mississippi River Commission, the problem grows yearly more and more intricate. Yet just so far as this confidence is expressed in settlements within the area

liable to an overflow so much further must the levees protect beyond any chance of disaster. If we could count on compensating occurrences to arise at every bank-full stage, our levee system would be likely to be a safeguard against inundation, although the 1912 flood will, in a large measure, belie the contention. It is not to be expected that all the conditions favorable to floods should occur at once, but it is possible for them to do so, and the assertion is safe that unless the extreme volume of water which can be figured as a possibility in any Mississippi River flood can be cared for by the levee system alone, the public money should be turned to some more efficient means of protection. Just meeting the limit of strain or preventing a break only by excessive vigilance and energy or saving from disaster by some mitigating circumstance is not the end to be aimed at; but to be as reasonably sure as it is given man to be that an overflow cannot occur must be the plan. In many instances the limited area of rainfall has saved the levees; during 1903, the low stage of the river just before the flood was beneficial; during 1907, a cold wave came on and checked the rise in all the tributaries north of Cairo. The engineers of the first district labored with difficulty in almost continuous rains and prevented a break into the White River basin with great effort. Had not the weather turned cold on February 3d, they infer that in spite of their labors a break

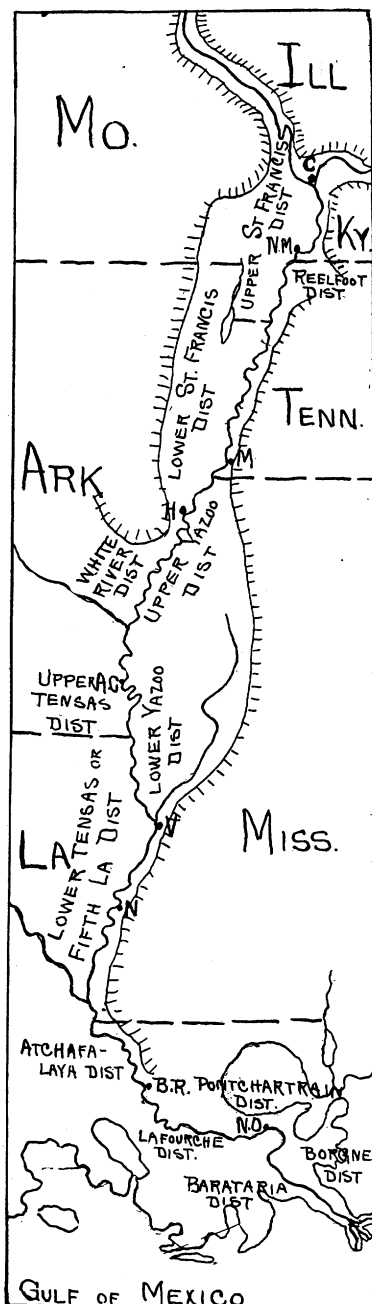


FIG. 4.—Map of Lower Mississippi, showing locations of Levee Districts, and important points. C., Cairo; N. M., New Madrid; M., Memphis; H., Helena; A. C., Arkansas City; V., Vicksburg; N., Natchez; B. R., Baton Rouge; N. O., New Orleans.

would have occurred. As it was, the levees were topped. The arrival of the cold wave prevented a greater flood and furthermore so checked the supply of water that the flood was of short duration in the upper portions of the alluvial basin. In 1912, the abnormally low amount of precipitation which fell in upper Mississippi drainage area, and therefore the lack of an extra volume of water from a source which rarely fails, opens a possibility for the levee advocates to consider seriously.

TABULATED STATEMENTS.

1. Extreme stages during recent floods on the Mississippi River for eleven stations.

STATIONS	HIGH WATER OF THE YEAR (IN FEET)					FLOOD STAGE
	1882	1897	1903	1907	1912	
Cairo	51.87	51.67	50.60	50.30	54.00	45.00
Memphis.....	35.15	37.66	40.10	40.30	44.90	33.00
Helena	47.20	51.75	51.00	50.40	54.20	42.00
Arkansas City....	47.10	51.90	52.90	52.10	55.40	42.00
Greenville.....	41.68	46.75	49.10	47.30	50.50	42.00
Lake Providence. .	38.32	44.54	46.48	46.30	48.25	42.00
Vicksburg	48.75	52.48	51.80	49.60	51.90	45.00
Natchez.....	47.75	49.82	50.35	48.90	51.40	...
Baton Rouge.....	35.95	40.65	40.05	37.40	43.80	
New Orleans.....	15.80	19.50	20.30	19.80	21.40	16.00

The 1912 flood furnished record heights at all the stations in the above table, with the exception of Vicksburg, where the flood height fell below the previous highest stage of 1897.

2. The present condition of the levee system, from the last Annual Report of the Mississippi River Commission (Fig. 4).

LEVEE DISTRICT	MILES IN SYSTEM	PERCENT. NOW BUILT	APPROX. AREA IN SQ. MILES PROTECTED
Upper St. Francis.....	92.00	31.3	700
Lower St. Francis.....	212.00	82.5	3,500
White River.....	74.00	67.3	910
Reelfoot.....	21.00	64.2	310
Upper Yazoo.....	124.00	100.0	3,281
Lower Yazoo.....	207.60	82.3	3,367
Upper Tensas.....	192.90	81.0	2,500
Lower Tensas.....	157.54	81.9	2,080
Atchafalaya.....	127.22	87.2	6,085
Lafourche	82.23	85.5	
Barataria.....	71.88	73.3	2,020
Pontchartrain.....	125.78	87.6	
Lake Borgne.....	78.10	75.6	1,816
Total.....	1,565.25	81.7	26,569

The only district that was not inundated and the only levee reach which withstood the 1912 flood without a crevasse was the Upper Yazoo. This is the only levee district with completed levees.

3. Rainfall for January, February and March, 1912. From *The National Monthly Weather Bulletin, Weather Bureau* (in inches).

STATIONS	JANUARY		FEBRUARY		MARCH	
	NORMAL	DEPARTURE	NORMAL	DEPARTURE	NORMAL	DEPARTURE
Vicksburg	5.67	—1.95	4.74	—2.04	6.25	+1.19
Little Rock.....	4.79	—1.25	4.34	—1.60	4.94	+4.11
Memphis	5.21	—1.80	4.49	—0.74	5.77	+3.76
Cincinnati	3.36	—1.15	3.33	—1.22	3.64	+1.09
Cairo	3.82	+0.31	3.44	—1.03	4.02	+1.27
St. Paul.....	0.90	—0.38	0.87	—0.80	1.60	—1.28
Lincoln, Neb.....	0.62	—0.55	0.74	+0.57	1.33	+0.73
Wichita.....	0.77	—0.65	1.12	+1.20	2.25	+0.82

For the eight stations, the total departure for January was — 7.35 inches, for February, — 5.66 inches and for March, + 11.69 inches.

THE EXPEDITION OF THE ROYAL DANISH GEOGRAPHICAL SOCIETY TO ARABIA

PRELIMINARY REPORT

BY

BARCLAY RAUNKIÆR*
Copenhagen

On Nov. 12, 1911, I left Copenhagen for Constantinople, having been commissioned by the Royal Danish Geographical Society to make a reconnaissance journey in Northeastern Arabia. Through letters of introduction supplied by the Exploration Committee of that Society I received valuable support from the Turkish Government and from the Swedish-Danish representative, Minister v. Anckarsværd. I left Constantinople on Nov. 28 and crossed Asia Minor by the Anatolian and the completed portion of the Bagdad railroads. From Ulu-Kishla, which is the last station on the northern slopes of

* Mr. Raunkier was known before this journey as a writer on the geography of plants and by his expedition to Central Tunis.